GRAPHICAL USER INTERFACE LOAD FLOW SOLUTION OF RADIAL DISTRIBUTION NETWORK

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Abstract: Power flow computation of a distribution system is very important for the system operation, reconfiguration and for placing the FACTS devices. This paper presents a development of distribution Power System of Radial Distribution Network with laterals Load Flow Analysis tool based on the Tellegen theorem based method by using a User Friendly Graphical User Interface (GUI) Matlab Program. This tool introduces a simple interface for the user to perform load flow analysis. It is also designed for a user to view power flow results for each iteration and thus will facilitate especially undergraduate electrical students to verify their manual calculation of load flow solution. By just point and click, the students will easily get the required solution. The load flow tool is evaluated by solving the load flow of several test systems and the GUI tool gives the complete Voltage Profile and Power Losses in the system.The well proved Tellegen theorem is used to obtain the load flow solution of Radial Distribution Network. 12.6KV Distribution system for 12, 28, 33 and 69 bus system..The result shows that all the answers displayed in GUI for every required calculation steps for Tellegen theorem based load flow are successfully verified with the manual calculation Thus, this tool helps student and lecturer to learn and verify their manual calculation and at the same time reduce their calculation time.

Keywords: **GUI(Graphical User Interface) tool ; Radial Distribution Network; Tellegen theorem.**

I.INTRODUCTION

The distribution network structure is radial with laterals and sublaterals. The network branches have high r/x ratio. Due to these features the conventional load flow studies fail to converge.

Luis A F.M.Ferreira[1] et al proposed the idea of Tellegen theorem application for Power systems. Hsia-Dong Chiang[2] et al developed decoupled load flow method for distribution networks. D.Das [3] et al proposed a novel method for solving radial distribution networks. S. Sivanagaraju[4] et al proposed a loop based load flow method for weakly meshed distribution network. [2][4]papers had higher order terms and trigonometric equations. Memory storage requirement were high and it involved high computational time. The authors of this paper [5] and [6] have proposed and applied Tellegen theorem algorithm for load flow solution of radial distribution network. It is proved to have less memory storage requirements and computational time.

The simple and well proved Tellegen theorem algorithm is used for load flow analysis of the distribution network. It has good convergence rate. The algorithm is applied to the distribution network without and with laterals. At start flat voltage profile is assumed. The objective and other necessary equations used in this process does not have any higher order terms and trigonometric functions.and the memory is observed to be less and computation time is also less. The voltage magnitudes at every node along along with active and reactive power losses in the network.

Load flow solution is required for continuous monitoring of the system. The solution is necessary for future expansion of the system and is used in various ways, i.e, for reconfiguration of the system, load changes, voltage profile improvement and design of the protection equipment. In this process the algorithm has to be execute large number of times. Algorithms which give accurate solutions have to be adopted. At the same time reading the data with a user friendly tool is always appreciable. The Substation Engineer requires the complete solution of the system along with the interconnections with a click of a button. Input data along with the results with a pictorial representation of the system in one single window gives the idea of the system at a glance. An attempt to achieve the above is made in the paper.

II. RESEARCH METHOD

A.Load Problem Formulation

Load flow solution of radial distribution network

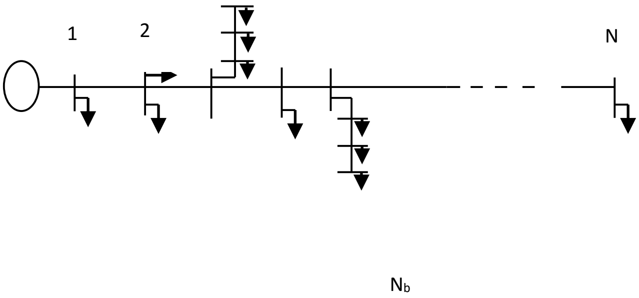

Fig1. Radial Distribution network with laterals

The Tellegen theorem is that "Sum of instantaneous complex powers in a network is equal to zero",

$$\sum_{k=1}^{N_b} V_k I_k^* = 0 \qquad (1)$$

V_i and I_i represents the voltages and currents at the ith buses respectively.
For the given distribution network

$$(0-V_1)I_1 + (V_1 - V_2)I_1 + P_{L1} + jQ_{L1} + (V_2 - V_3)I_2 + .$$
$$...(V_{NB-1} - V_{NB})I^*_{NB-1} + P_{LNB} + jQ_{LNB} = 0 \qquad (2)$$

The loads at each node are represented by $P_{Li}+jQ_{Li}$..
The voltage at (i+1) th node is obtained with ith voltage known.

$$V(i+1) = \frac{(V(i)*V(i) - k3)}{V(i)} \qquad (3)$$

The power injected at the ith bus is given by P(i)+jQ(i). The resistance and reactance at the ith bus is represented by r(i)+jx(i).

where $k3 = \sqrt{(P(i)^2 + Q(i)^2)(r(i)^2 + x(i)^2)}$ (4)

The distribution system with laterals is solved in in two stages [1] and [2]

1)First stage
Initially the loads at the laterals are lumped at their respective start nodes thus reducing it to a main feeder case.The load flow study for main feeder case is executed.

2)Second stage
Now the voltage at the node where the lateral is connected is taken as the source node. The algorithm for the load flow is run at each lateral. This gives the entire load flow solution.

B.Graphical User Interface Tool

A Graphical User Interface tool developed in Matlab environment which gives the complete load flow solution of radial distribution network with laterals. The load flow solution includes voltage profile and power losses. A network diagram is displayed along with the Load Flow Solution. The diagram indicates the interconnection of the buses and the voltage at the corresponding bus.

C.Sequence of steps involved in developing the tool

Matlab Graphical User Interface is used to develop this user friendly tool.

1. Input data required for load flow solution are to be read. Static text, edit text, tables are used in order to read the data. Input data includes
   (i) Number of buses, number of laterals, sublaterals.
   (ii) Lateral connection data: number of laterals connected at each node.
   (iii) Source Node, Start node and end node of laterals. The node at which lateral is connected is called source node. The node number of the lateral after the source node in the lateral is called start node. The last node number of that lateral is called end node.
   (iv) Resistance and Reactance data of the lines in pu
   (v) Active and Reactive power loads at each bus in pu
2. A push button is used to execute the algorithm for load flow solution of the fed radial distribution network.
3. The well proved Tellegen theorem algorithm is programmed and linked with the pushbutton for execution.
4. On execution the results are displayed on the panel and the tables

(i) in pu at each bus and power losses in KW and KVAR of the system are displayed in two separate tables.

(ii) The connections of the nodes are displayed in the panel. The connections indicate the main feeder along with its laterals

(iii) The bus number with their corresponding voltages are displayed on the plot axes.

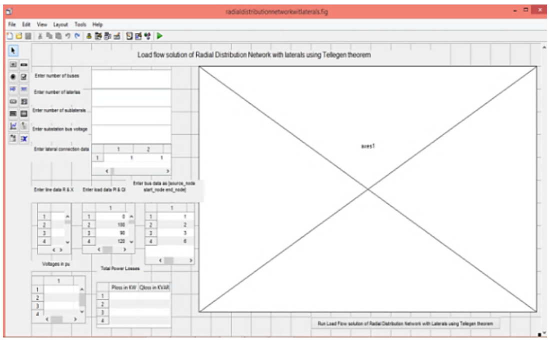

Fig2. Graphical User Interface tool for Load flow solution of Radial Distribution network with laterals

The GUI tool shown in Fig2 is modeled with text boxes to enter the feeder data with number of buses, laterals, sublaterals. Tables are provided to enter the data of lateral connection data, line data and load data. After execution the connection diagram of the buses is generated at a click of the push button along with the voltage profile and power losses of the system. The output values are shown in the tables provided. The connection diagram is displayed in the plot axes.

III.RESULTS AND DISCUSSIONS

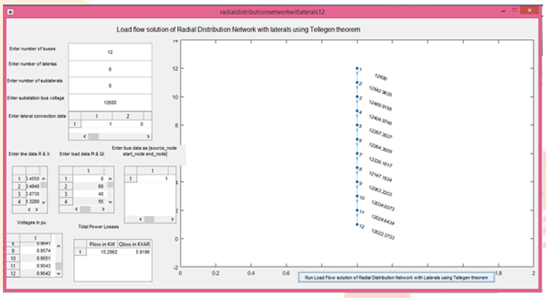

Fig 3. Load flow solution of 12.6KV, 12 bus Radial Distribution network – main feeder case.

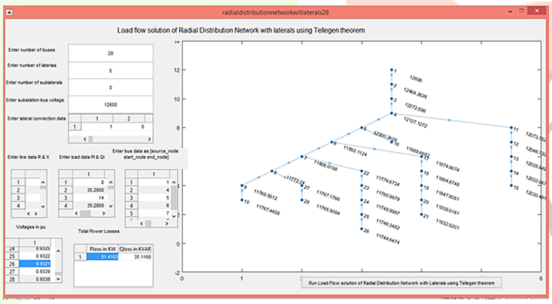

Fig 4. Load flow solution of 12.6KV, 28 bus Radial Distribution network with laterals

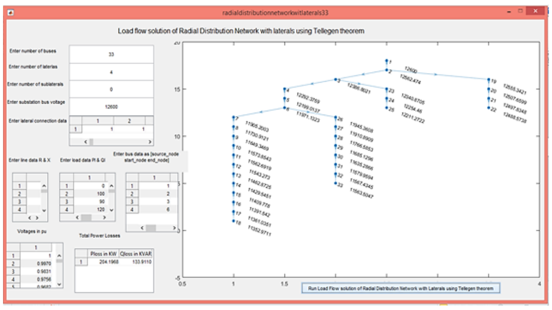

Fig 5. Load flow solution of 12.6KV,33 bus Radial Distribution network with laterals

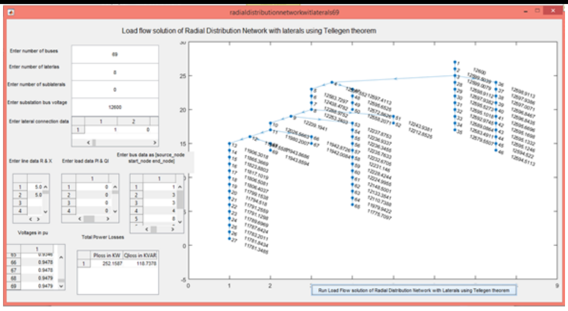

Fig 6. Load flow solution of 12.6KV,69 bus Radial Distribution network with laterals

TABLE1

	12 bus	**28 bus**	**33 bus**	**69 bus**
Power Losses in KW	15.28	51.41	204.19	252.15
Power Losses in KVAR	5.91	35.11	133.91	118.73

Power Losses in 12.6KV Radial Distribution network- 12 bus, 28 bus, 33 bus and 69 bus

Figures 3 to 6 give the picture of the load flow data along with the voltage profile, power losses and interconnection of buses for 12.6KV-12, 28,33 and 69 buses. 12 bus system is a simple radial feeder without laterals. 28,33 and 69 buses are radial feeders with laterals. The power losses and voltage profile for all the systems are tabulated separately in Tables 1 and 2.

TABLE II

S.No	**12 bus**	**28 bus**	**33 bus**	**69 bus**
1	1.0000	1.0000	1.0000	1.0000
2	0.9955	0.9892	0.9970	0.9999
3	0.9913	0.9740	0.9831	0.9999
4	0.9845	0.9633	0.9756	0.9998
5	0.976	0.9524	0.9682	0.9987
6	0.9734	0.9439	0.9501	0.9872
7	0.9711	0.9370	0.9449	0.9753
8	0.9641	0.9343	0.9310	0.9725
9	0.9574	0.9341	0.9246	0.9714
10	0.9551	0.9339	0.9186	0.9545
11	0.9543	0.9582	0.9177	0.9508
12	0.9542	0.9561	0.9161	0.9482
13		0.9552	0.9098	0.9449
14		0.9550	0.9071	0.9417
15		0.9548	0.9055	0.9384
16		0.9515	0.9041	0.9379
17		0.9424	0.9017	0.9370
18		0.9417	0.9010	0.9370
19		0.9403	0.9965	0.9364
20		0.9396	0.9927	0.9361
21		0.9391	0.9919	0.9358
22		0.9347	0.9912	0.9358
23		0.9334	0.9794	0.9357
24		0.9325	0.9726	0.9355
25		0.9322	0.9691	0.9352
26		0.9321	0.9480	0.9351
27		0.9339	0.9453	0.9350
28		0.9338	0.9339	0.9999
29			0.9274	0.9998
30			0.9234	0.9996
31			0.9190	0.9996
32			0.9181	0.9994

33			0.9177	0.9991
34				0.9987
35				0.9984
36				0.9999
37				0.9998
38				0.9998
39				0.9997
40				0.9997
41				0.9997
42				0.9996
43				0.9996
44				0.9996
45				0.9996
46				0.9996
47				0.9998
48				0.9997
49				0.9978
50				0.9967
51				0.9717
52				0.9693
53				0.9713
54				0.9712
55				0.9711
56				0.9711
57				0.9708
58				0.9707
59				0.9705
60				0.9702
61				0.9642
62				0.9630
63				0.9612
64				0.9508
68				0.9346
66				0.9478
67				0.9478
69				0.9479
69				0.9479

Voltage Profile of 12.6KV Radial

Distribution network- 12 bus, 28 bus, 33 bus and 69 bus

IV.CONCLUSIONS

Graphical user interface tool developed using Matlab 2015a has been tested with various number of feeders. Data and output results are shown in the same window. The tool has been developed to visualize data and output in the same window. At a click of the push button, solution appears on the screen. It is a user frientdly tool which clearly indicates input information and the outputs. As previously, programs need not be executed every time. Data can be easily modified in this window, instead of re-entering every time in the command window whenever there is change in data.

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